Hypersonic Project Overview
Fundamental Aeronautics Program
2008 Annual Meeting

Dr. James L. Pittman, Principal Investigator
Dr. F. McNeil Cheatwood, Project Scientist
Mr. John M. Koudelka, Project Manager

October 7, 2008
Atlanta, GA

Agenda

Project Mission & Structure

Discipline Overviews

Major Upcoming Events & Concluding Remarks

Mission Statement

Conduct fundamental and multidisciplinary research to *enable* air-breathing access to space and high-mass entry into planetary atmospheres

Through Discipline-based Research

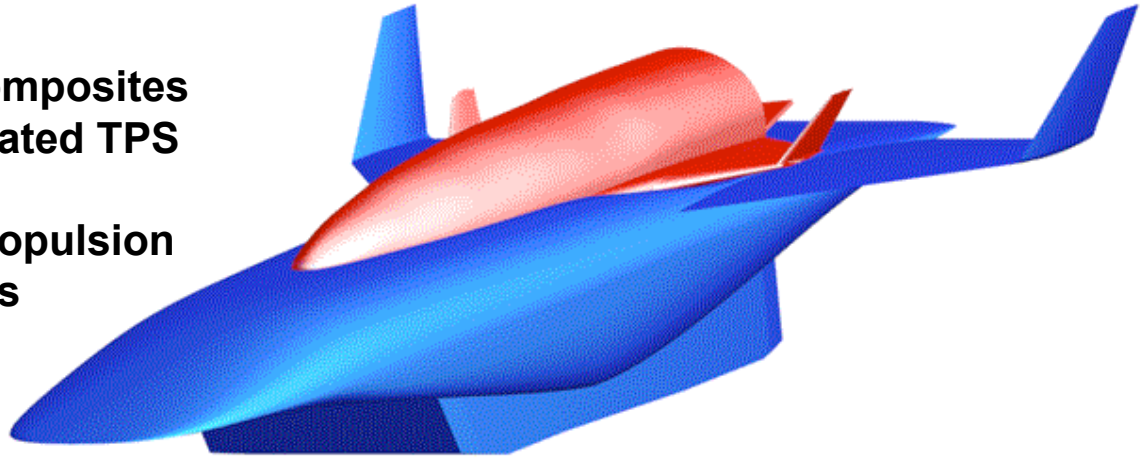
Technical Disciplines

- Materials & Structures
- Propulsion
- Aerodynamics, aerothermodynamics and plasmadynamics
- Guidance, Navigation & Control
- Experimental Capabilities
- Propulsion Technology Integration
- Physics-Based Multi-Disciplinary Analysis & Optimization

Hypersonics Project Focus

Highly Reliable Reusable Launch Systems (HRRLS)
NASA Two Stage To Orbit (TSTO) Reference Vehicle

Ceramic Matrix Composites
Structurally-integrated TPS
Hot Structures
Actively-cooled propulsion
Integrated Controls



CFD Methods
Physics-based Models
Physics-based MDAO
Vehicle Studies

Turbine-based Combined Cycle Propulsion
Rocket-based Combined Cycle Propulsion
Combustion Physics
Non-Intrusive Diagnostic Tools

Hypersonics Project Focus

High-Mass Mars Entry Systems (HMMES)

Ablators
High Fidelity Ablation Models
Flexible TPS

CFD Methods
Physics-based Models
Physics-based MDAO
Vehicle Studies
Inflatable Re-entry Vehicles

Project Management Structure

Hypersonics Project Leadership

PI: Jim Pittman

PM: John Koudelka | **PS: Neil Cheatwood**

Technical Leadership Team

PB-MDAO (L4)
John Martin

Propulsion Technology Integration (L3)
Ken Suder

Materials and Structures (L1-L2)
Anthony Calomino

Propulsion (L1-L2)
Aaron Auslender

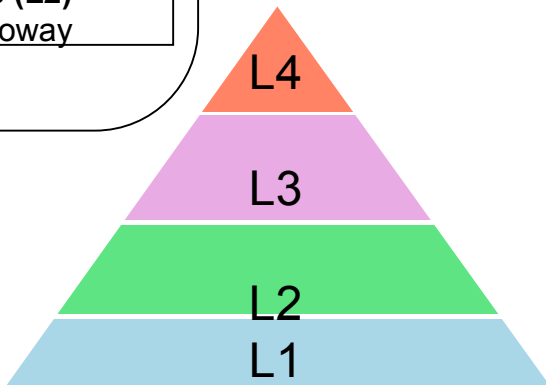
Aero/Aerothermo/Plasma Dynamics (L1-L2)
Seokkwan Yoon

Experimental Capabilities (L1-L2)
Robert Okojie

Guidance, Navigation & Controls (L2)
Don Soloway

Special Projects

IRVE-II	Mary Beth Wusk
HIFiRE Flight 2	Sal Buccellato
X-51	Sal Buccellato
Falcon HTV-2	David Glass
RATTLRS	Chuck Trefny



Management Team

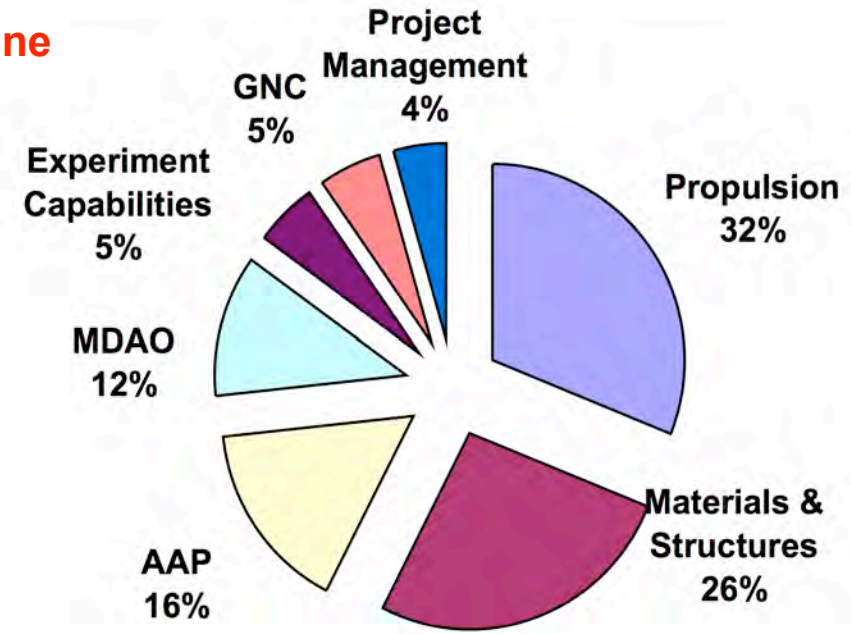
Associate PMs
Mario Perez
Darlene Pokora
Tim Risch
Jim Walker

NRA Manager
Karl Vaden

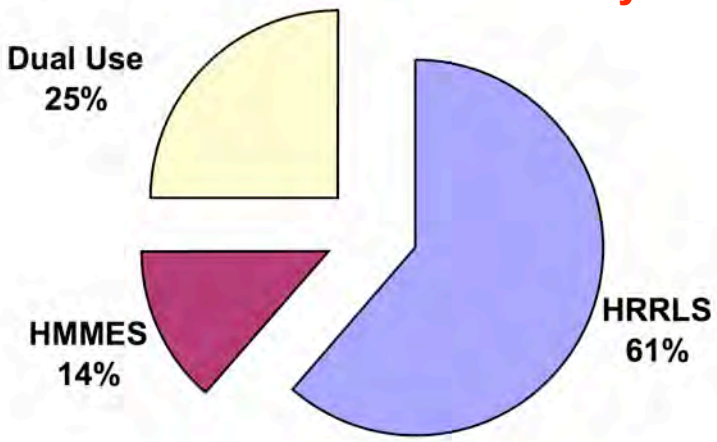
Business Team
Marie Daniels, lead

Investment Distribution

by Discipline



by Mission



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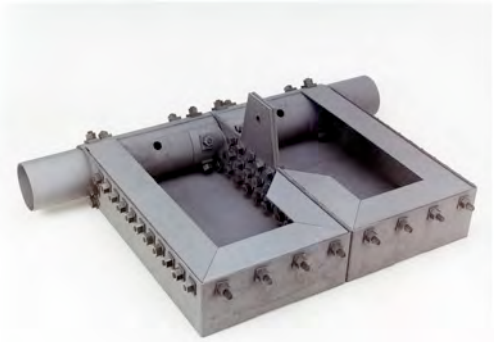
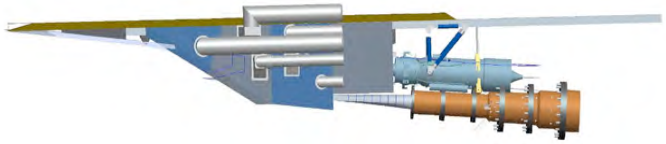
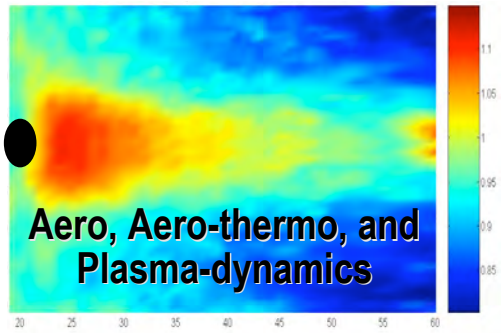
Hypersonic NASA Research Announcements



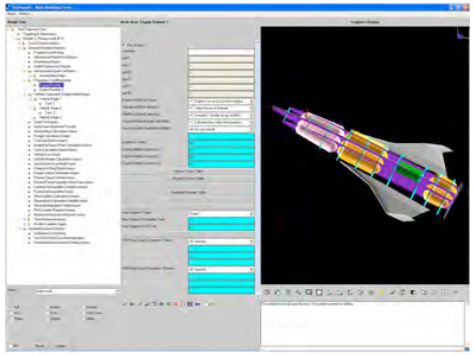
Materials & Structures



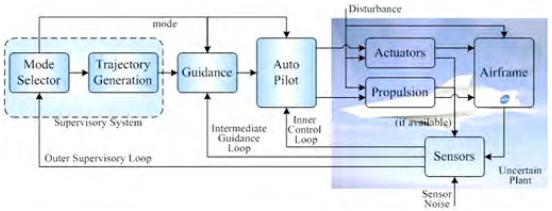
Air-breathing Propulsion



Experimental Capabilities



Multi-disciplinary Studies and Tools

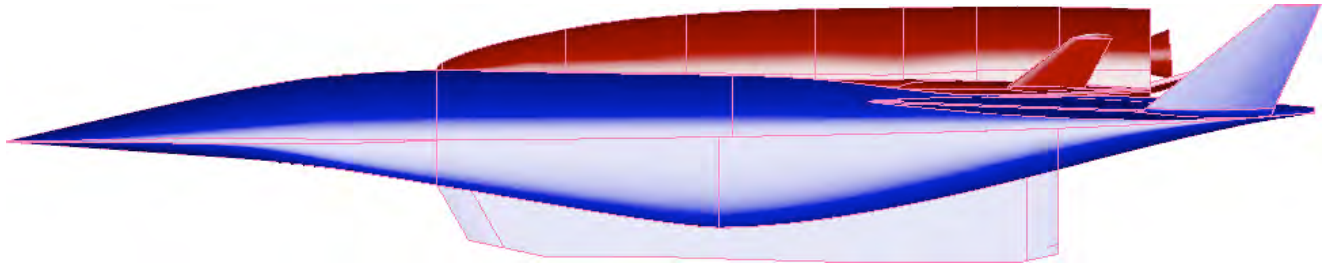


Guidance, Navigation & Control

3 NRAs: Total of 330 Proposals, 82 Awards, ~$50M over 4 years

National Hypersonic Science Centers

✓ **Laminar-Turbulent Transition**
(Boundary Layer Control)



✓ **Materials & Structures**

✓ **Air-breathing Propulsion**

Joint Effort with AFOSR

3 Centers

5 Years maximum with annual renewal

$30M maximum for all Centers combined

White Papers Due October 17, 2008

Final proposals due December 12, 2008

HyBoLT/SOAREX/ALV-X1 Mission

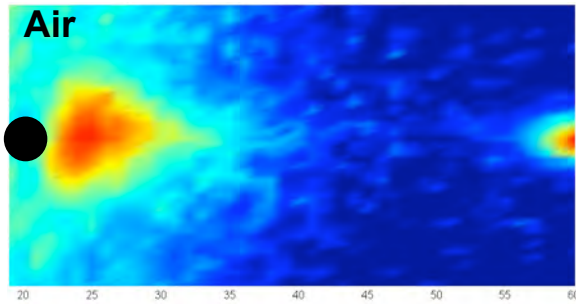
Wallops Island, Virginia

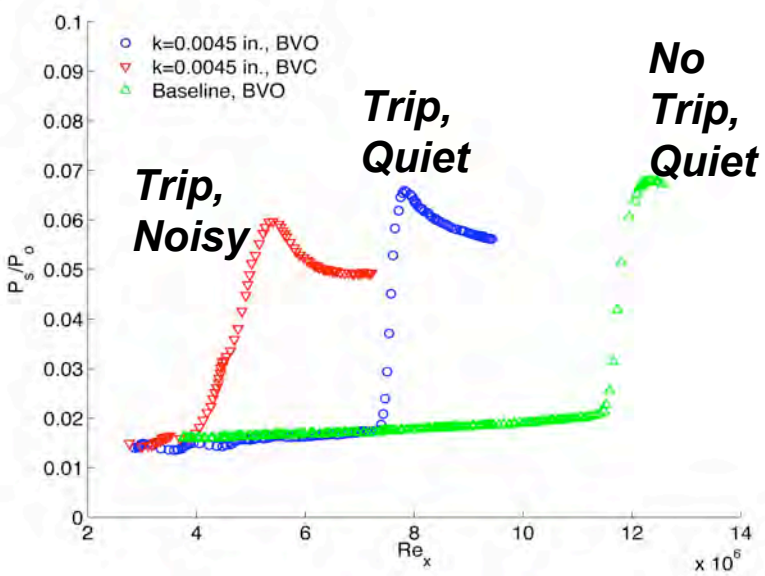
5:10 am, August 22, 2008

- **ATK rocket destroyed about 20 sec after liftoff as it veered sharply to the south.**
- **Hot-film sensors and data acquisition system functioned.**
- ***Hypersonic Boundary Layer Transition research will continue …***

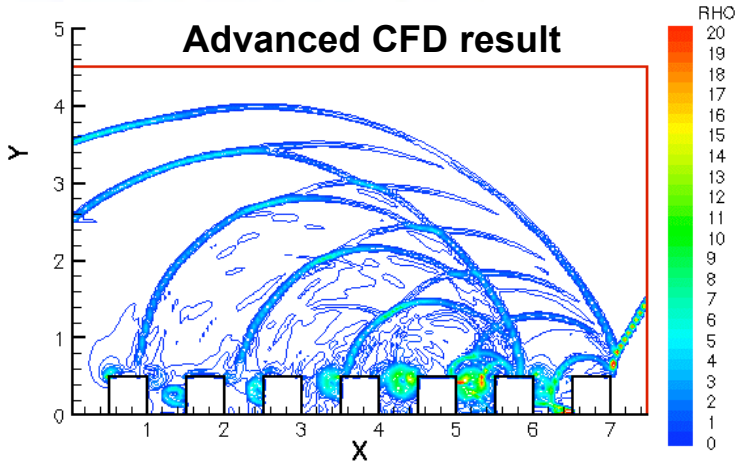
Aero/Aerothermo/Plasmadynamics

Reduce the uncertainty in aero-heating prediction by 50% (2005 baseline)





Quiet Tunnel results



HIFiRE-1 Phosphor Thermography
Mach 6 Tunnel

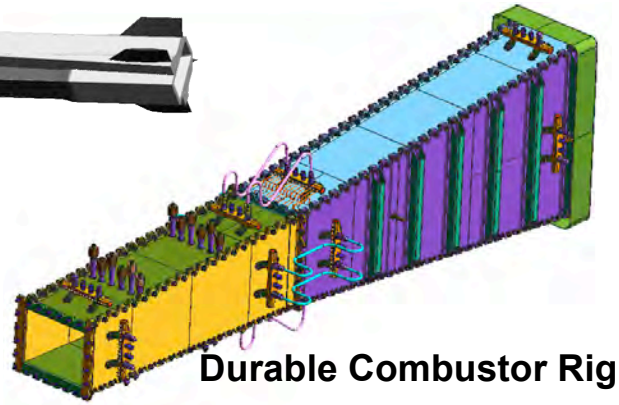
Air-breathing Propulsion Roadmap

Dual Mode Scramjet
- Actively Cooled Structure for long duration flight

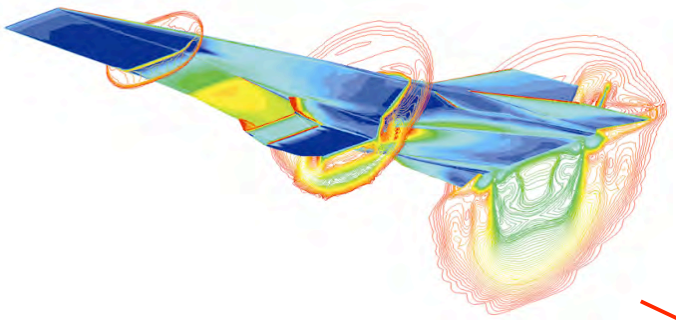
X-43A
- Integrated Vehicle Demonstration
- Scramjet Engine
- Short Duration Flight (Heat Sink Materials)

X-51A

Long Duration

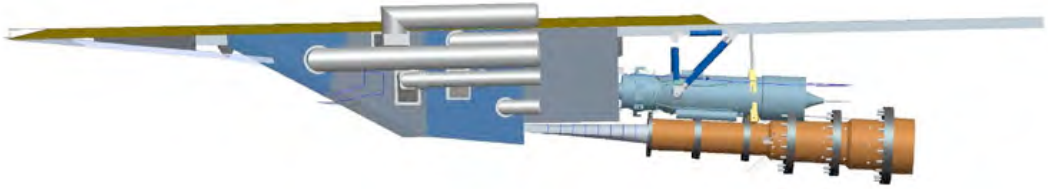


Durable Combustor Rig



Combined Cycle

Turbine-based Combined Cycle Rig



Flight Experimentation

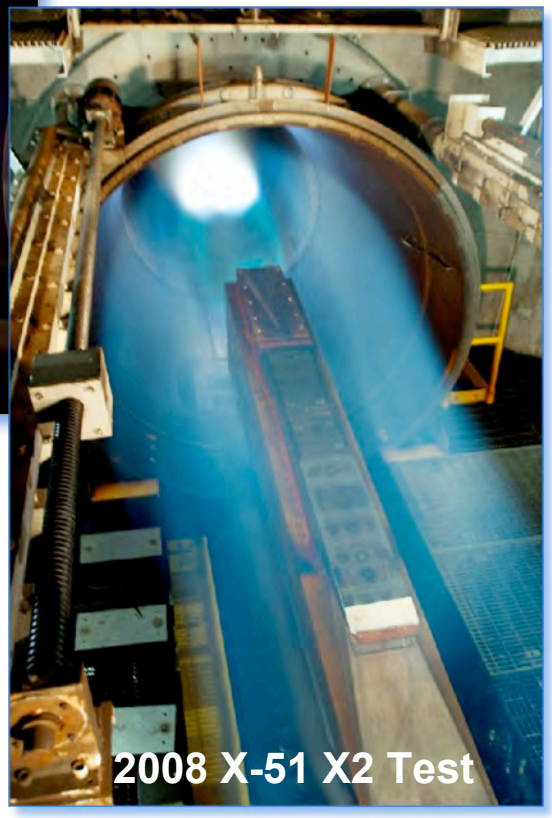
X-51A Program

Successful NASA testing in the 8' High Temperature Tunnel critical to X-51 Program

2009 X-51 Flight Test

2007 X-51 X1 Test

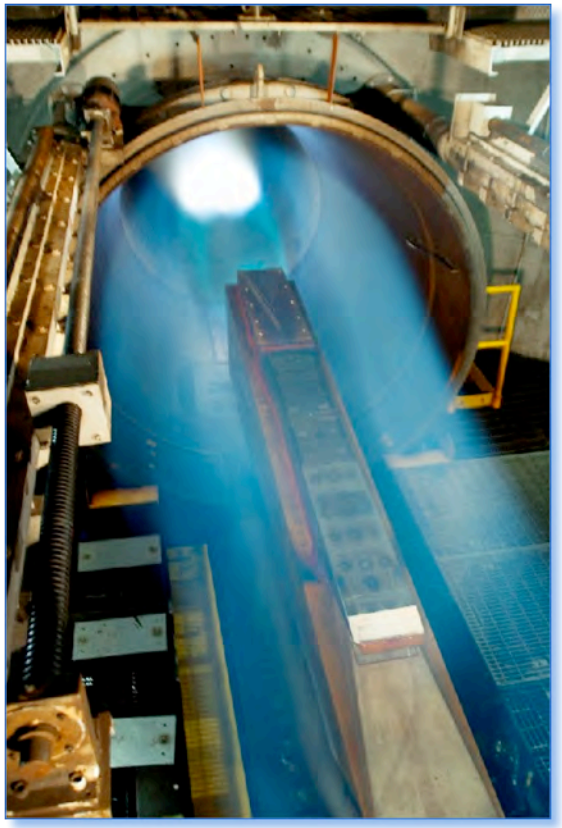
2006 GDE-2 Test



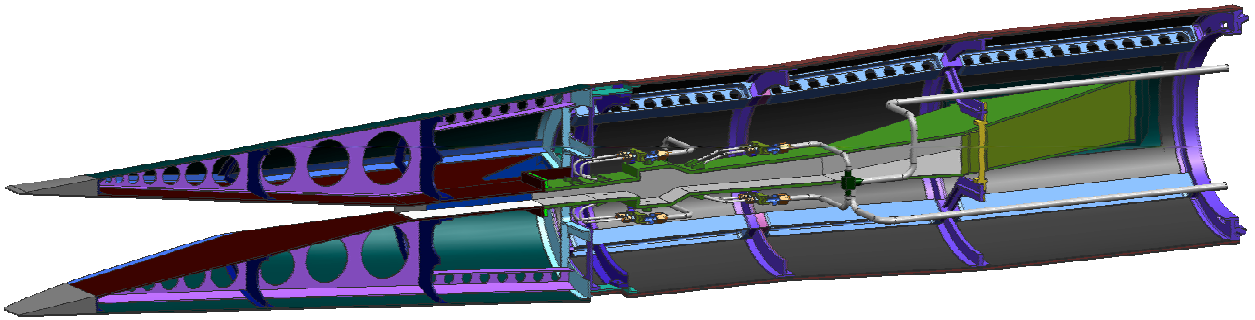
2008 X-51 X2 Test

Air-breathing Propulsion

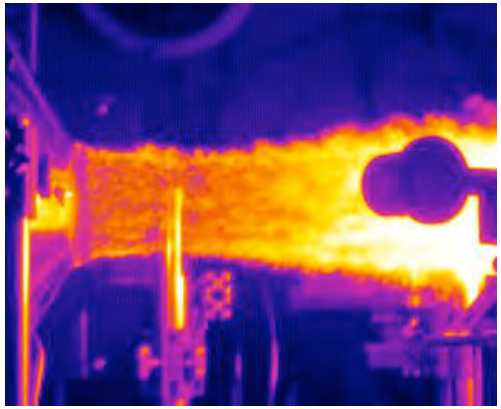
Advance understanding of supersonic combustion using advanced computational tools and diagnostics, ground-based facilities, and flight tests.



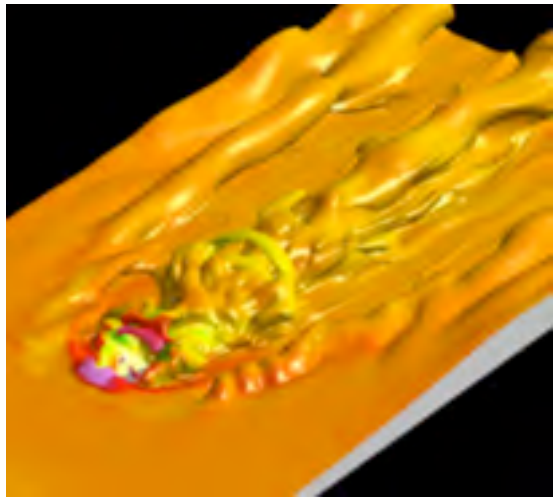
X-51 scramjet test in 8' HTT



HIFiRE Flight 2 scramjet schematic



IR image of H2 flame

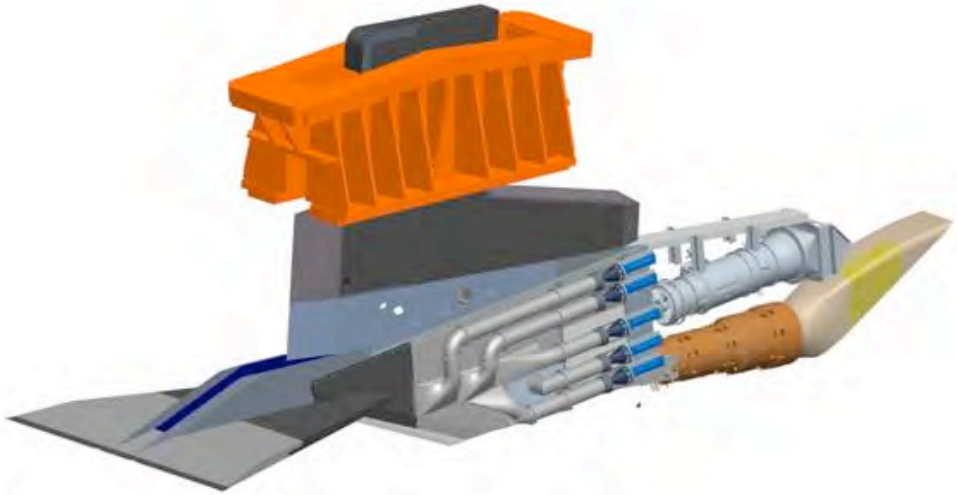


CFD simulation of fuel injection

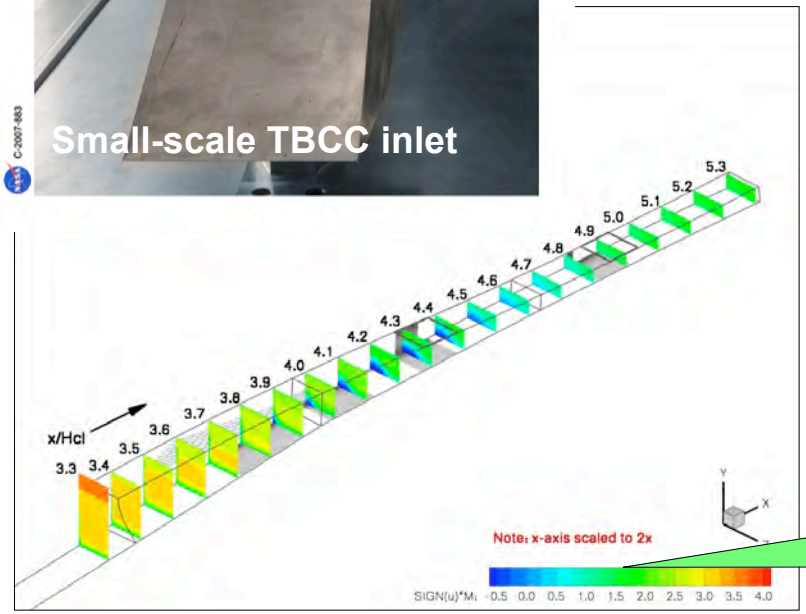
Propulsion Technology Integration

Develop combined-cycle propulsion system with focus on turbine to dual-mode scramjet transition.

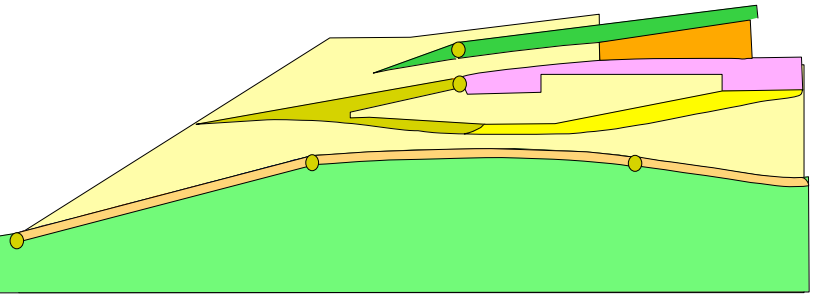
Small-scale TBCC inlet



Schematic of large-scale TBCC rig



CFD result in single flowpath

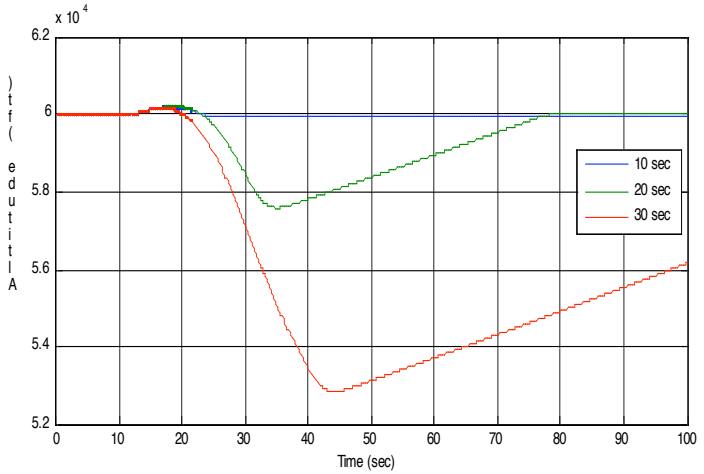


Side view showing dual flowpaths

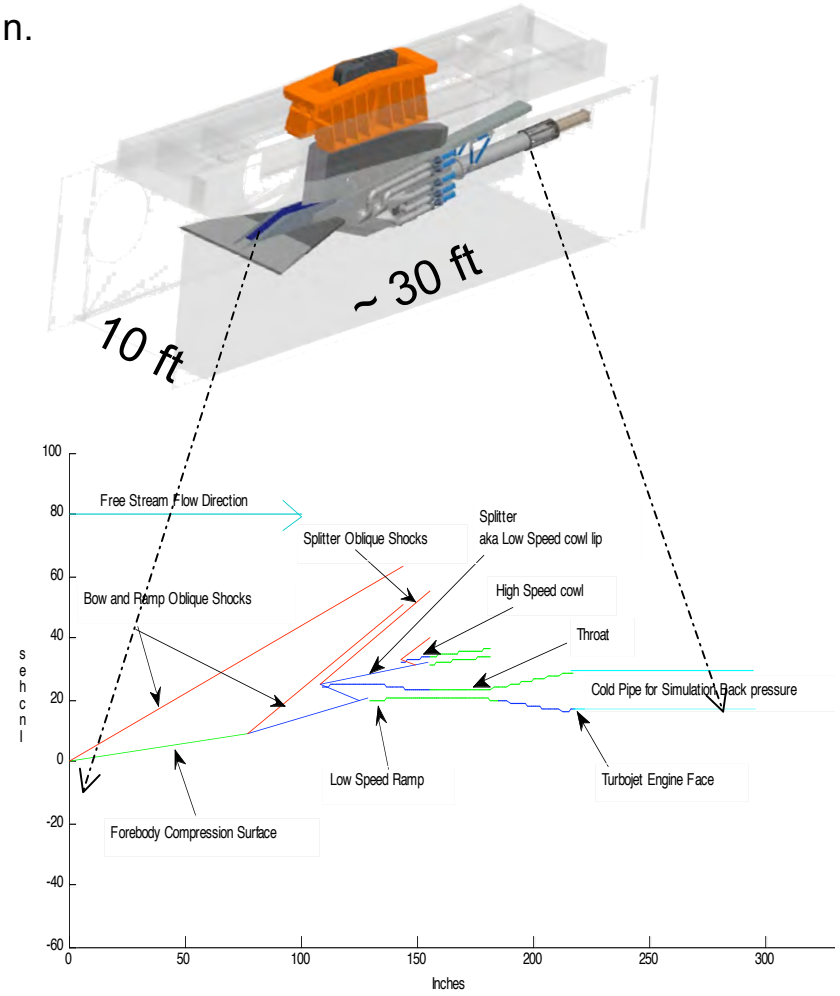
Guidance, Navigation and Control

Develop control design and analysis methodology to enable air-breathing hypersonic vehicles.

Develop design and analysis tools for conceptual design.



Vehicle Altitude Loss during Mode Transition



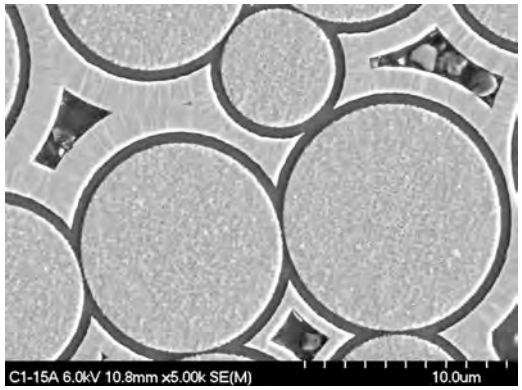
Interactive TBCC Simulator

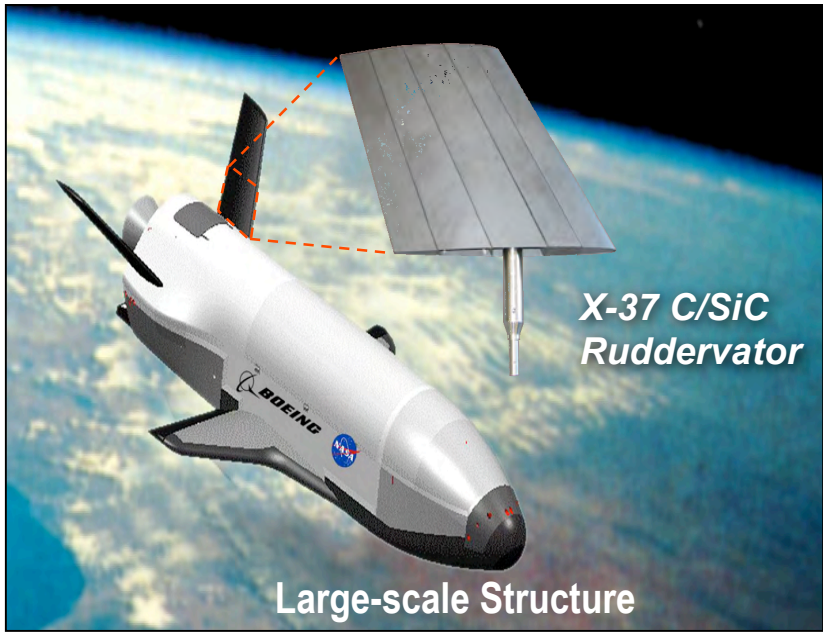
Materials & Structures

Develop 3000°F materials and structures for HRRLS Mission and advanced materials and structures (ablators and inflatables) for HMMES and other high-mass Missions.

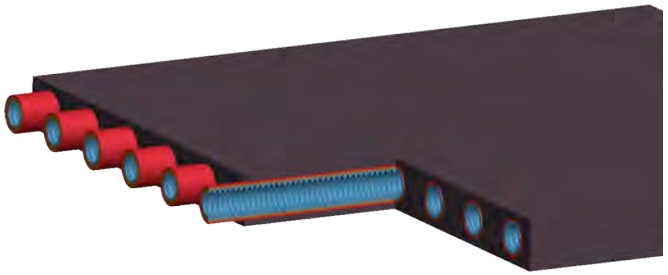
Structurally-Integrated TPS

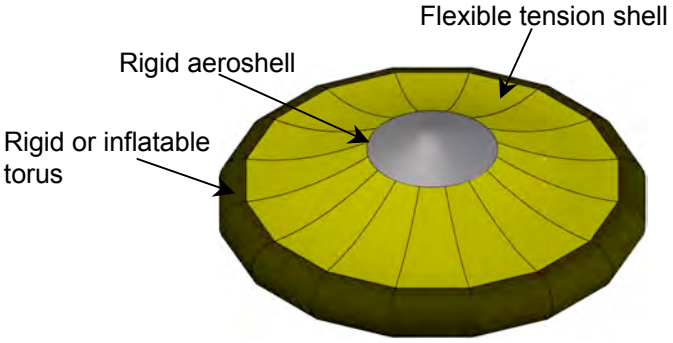
Materials Development





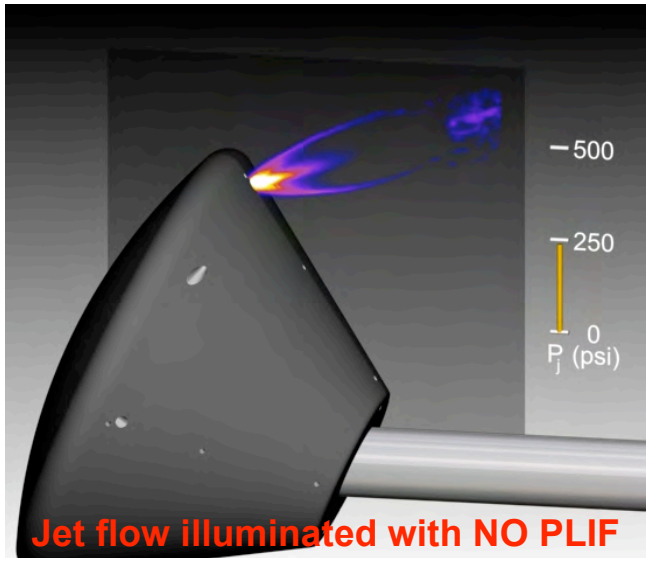
Actively-cooled Structure



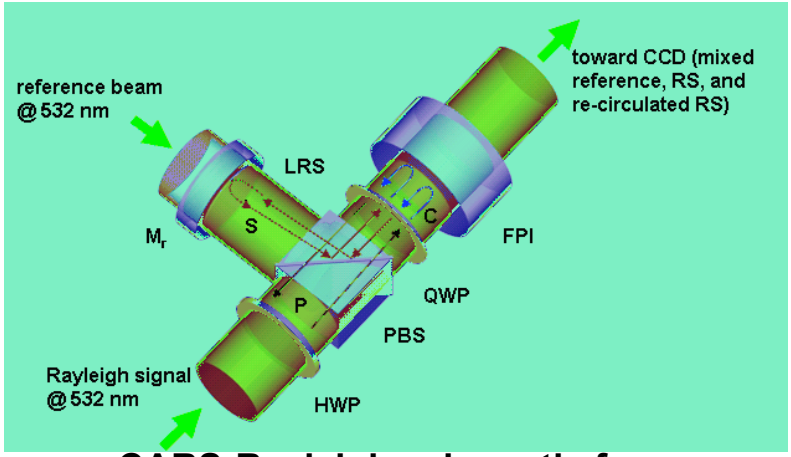


Experimental Capabilities

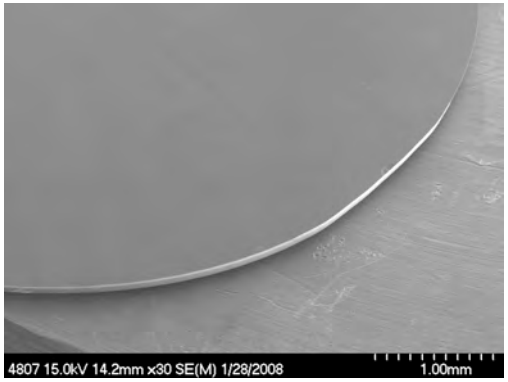
Develop non-intrusive diagnostics for hypersonic flows and high-temperature sensors.



600°C SiC pressure sensor



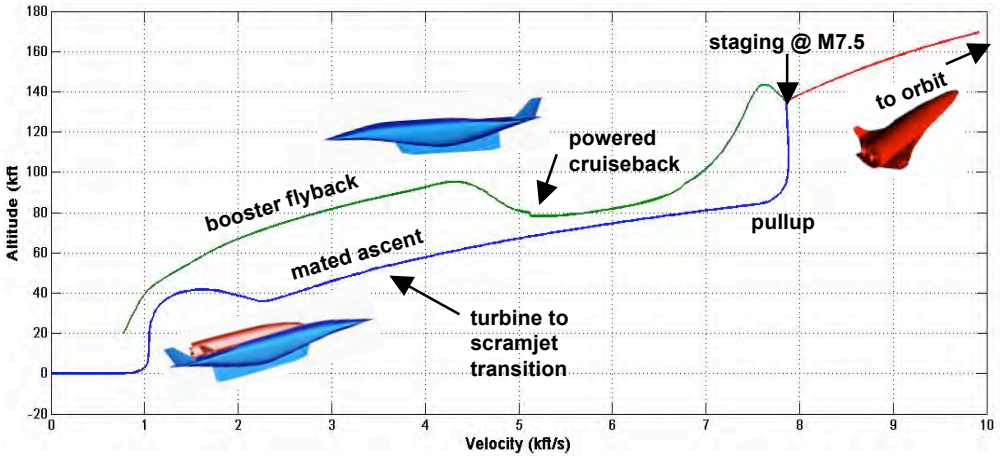
CARS-Rayleigh schematic for measuring species & velocity



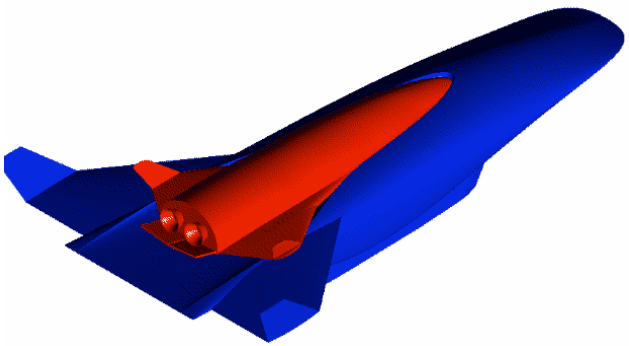
Circular SiC chip for embedding in pressure sensor

Physics-Based MDAO

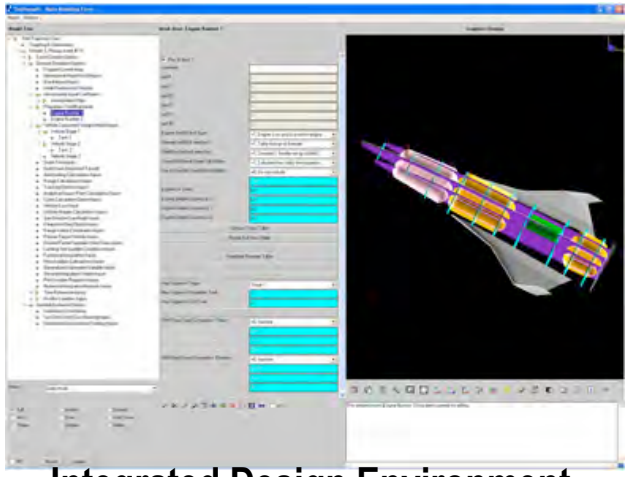
Create advanced vehicle concepts, develop integrated tools sets for analysis and design, and evaluate technology benefits.



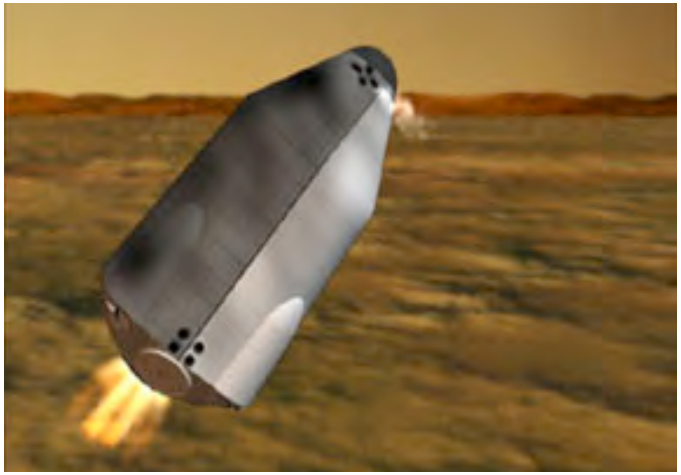
Mission Scenario



Air-breathing Two-Stage-to-Orbit Concept



Integrated Design Environment



High-mass Mars Concept

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Major Upcoming Events

National Hypersonic Science Centers

Inflatable Re-entry Vehicle Experiment (IRVE)-II

NASA/Air Force Air-breathing TSTO System Study

NASA High-mass EDL System Study

Mars Science Lander EDL Instrumentation (MEDLI)

Concluding Remarks

Excellent progress in all Disciplines

Hypersonics well-focused on tools and technologies to enable air-breathing access to space and high mass Mars entry

Emerging National “Team” for air-breathing access to space & NASA “Team” for high-mass Mars entry

Strong engagement with university community through NRAs